MICHIGAN DEPARTMENT OF ENVIRONMENT, GREAT LAKES, AND ENERGY

Ozone Attainment in Southeast Michigan: A Modeling Perspective

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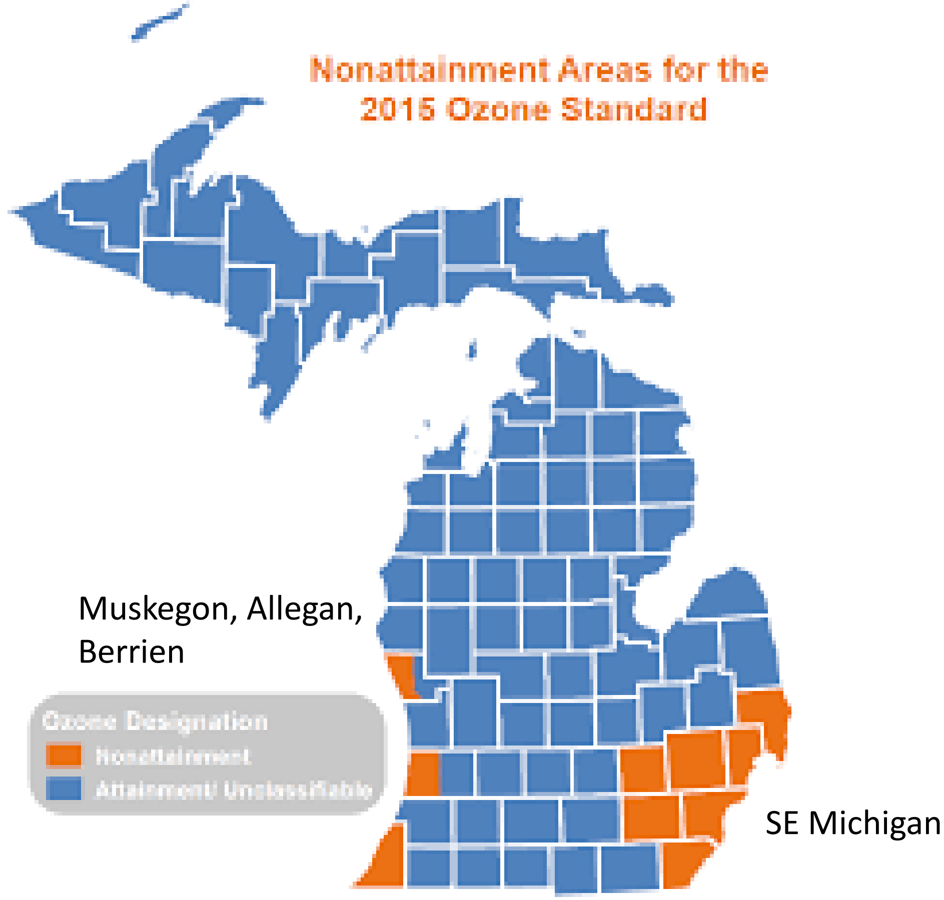
Ozone Non-Attainment Areas in Michigan



Possible Progression of the Ozone Attainment Process

- Ozone Design Value (3-yr average of 4th highest 8-hr concentrations at each monitoring site) must not exceed 70 ppb to attain O_3 National Ambient Air Quality Standard (NAAQS).
- All Michigan non-attainment areas currently designated as Marginal.
- Change in attainment status possible in 2021 based on Design Values computed from monitored concentrations in 2018, 2019, and 2020.
- If attainment not achieved by 2021, an area will be "bumped up" to Moderate Non-attainment, which will require:
  - Vehicle Inspection and Maintenance (I/M)
  - Stage 2 gasoline vapor recovery
  - Increased offsets (1.15:1 ratio instead of 1.1:1)
  - Reasonable Available Control Technology (RACT) for VOCs and NOx
  - 15% VOC Reasonable Further Progress (RFP) reductions
- An attainment demonstration must also be delivered by around 2023, to show ozone attainment by 2024.

4th highest monitored ozone concentrations in Southeast Michigan during 2018

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Elements of an Attainment Demonstration

- A conceptual model that reflects qualitative understanding of exceedances
- A baseline emissions inventory
- A projected future year emissions inventory reflecting proposed controls
- An ozone episode (start date to end date) reflecting typical ozone exceedances
- Meteorological simulation of the selected episode
- An air quality model configuration
  - Domain and resolution (usually a series of nested grids)
  - Choice of physical parameterizations
  - Chemical mechanism with corresponding emissions speciation
- A model performance evaluation (retrospective simulation vs. measurements)
- A control strategy test based on Relative Response Factors (RRFs)
- Optional: Weight of Evidence arguments

We Need a New Ozone Conceptual Model

- Numerical model used in a State Implementation Plan (SIP) attainment demonstration is conditioned by an inherent conceptual understanding.

- A conceptual model encapsulates our best understanding of:
  - The meteorological mechanisms that trap pollution in an airshed
  - The most critical source regions and downwind receptor areas
  - The source categories that most contribute to ozone exceedances
  - The specific ozone precursors most responsible for high ozone values.

- A **"black box" air quality model** that does not necessarily produce ozone in the same way as the real world may be **"stiff"** (unresponsive to simulated emission controls). **Expensive and ineffective control strategies may result**.

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Potential Benefits of a New Conceptual Model

- We may uncover **“low hanging fruit**” that we didn’t consider before (e.g., leaking underground pipelines, Detroit River barge traffic).

- We may avoid expensive wide-area approaches in favor of **“monitor-centric” control strategies** (“surgical knife” approach).

- **Control strategies may be shown to be more effective** if the resulting SIP air quality model is less “stiff” than alternative models based only on a generic understanding.

What Issues Require Improved Understanding?

High-resolution meteorological and air quality effects of the **lake breeze** and of the Detroit **urban heat island**.	•2007 Canadian BAQS-Met (Border Air Quality Study and Meteorological Study) showed that lake breeze front positioning relative to emission sources is important, and that urban structure can influence air quality significantly.
Chemical **source signatures** and **high-resolution plume structure** during ozone exceedances.	•Studies in Texas point to high resolution ozone plume structure in industrialized urban (Ship Channel) and rural (Barnett/Eagle Ford shales) areas.
Ozone productivity of the airshed, based on the **availability of radicals** and the **adequacy of radical precursor emissions**.	•Studies in Texas show the importance of primary formaldehyde emissions in determining the ozone productivity of the Houston airshed.

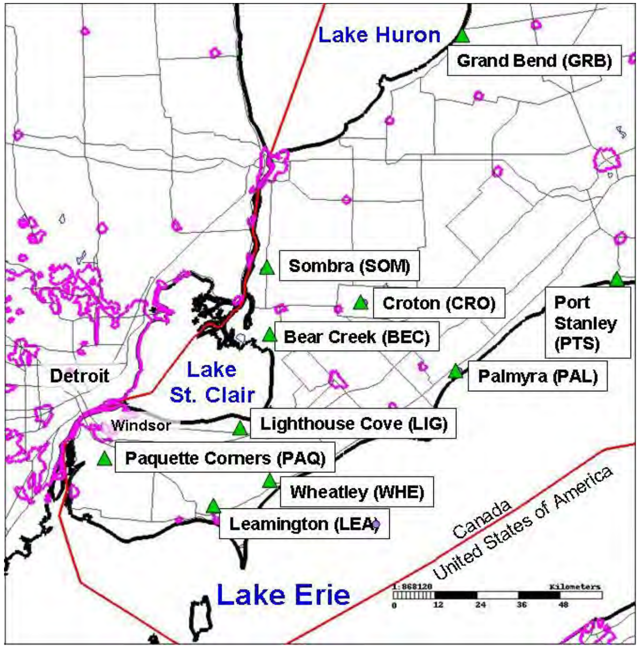

Fig. 1. Locations of BAQS-Met surface mesonet stations (green triangles). Urban region outlines in mauve, international border in red. (After Makar et al., 2010.)

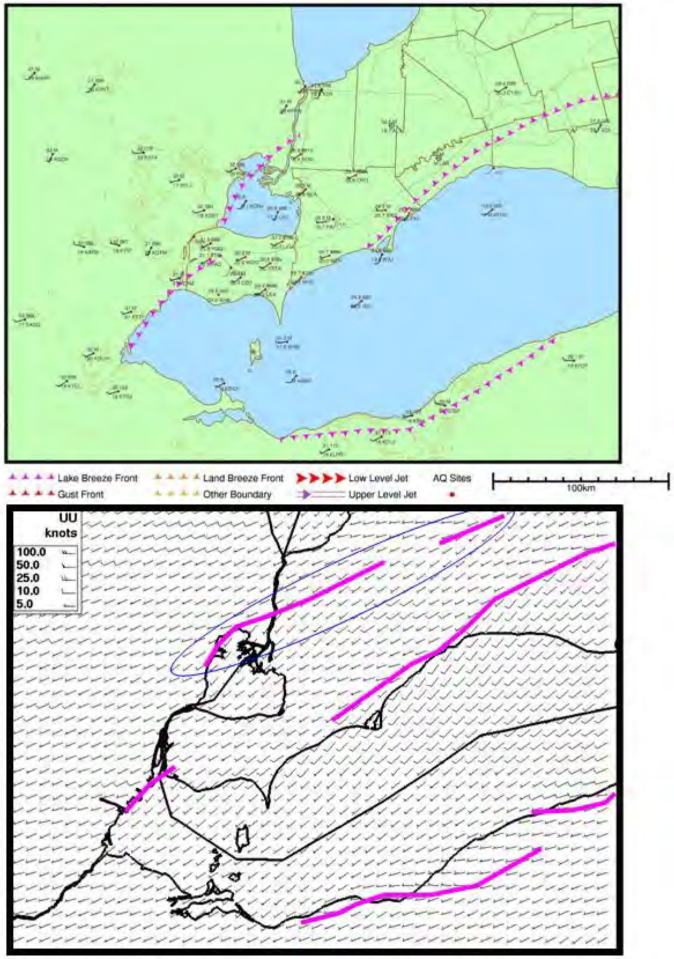

Fig. 2. 8 July, 17:00 UT (01:00 p.m. local time) **(a)** meso-analysis lake-breeze front locations; **(b)** lake-breeze front locations inferred from convergence pattern of 2.5-km resolution model winds. (After Makar et al., 2010.)

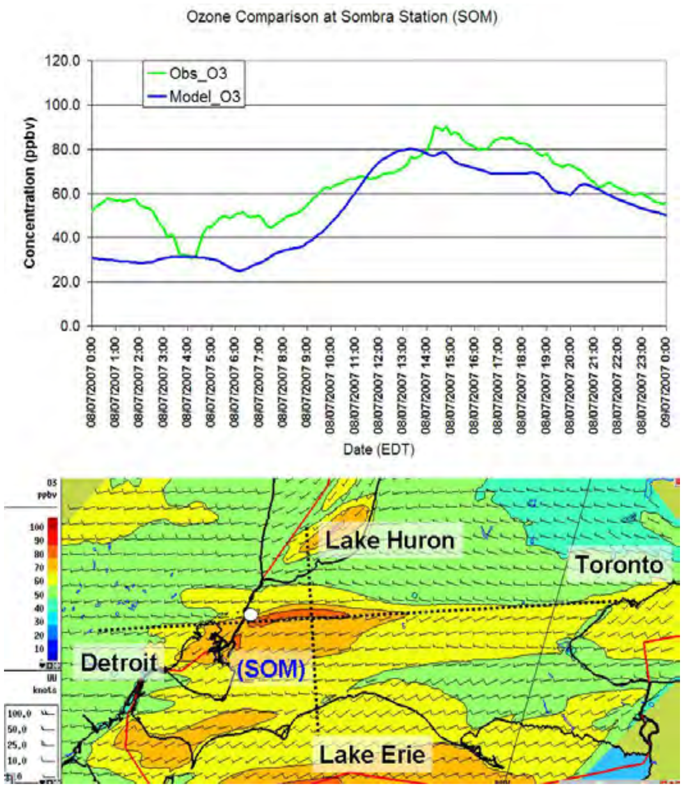

Fig. 3. **(a)** Model-predicted ozone versus observations, 8 July, Sombra station. **(b)** Model-predicted surface ozone and surface winds at 17:00 UT (01:00 p.m. local time). (After Makar et al., 2010.)

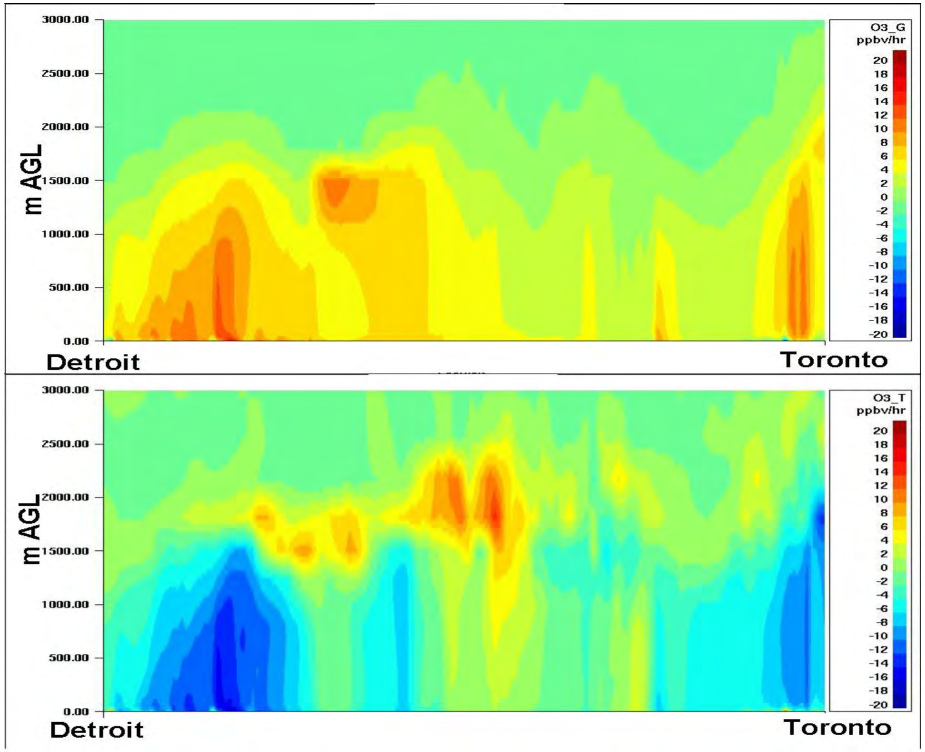

Fig. 4. Model-predicted ozone mass tracking fields for 8 July, 17:00 UT (01:00 p.m. local time), Detroit to Toronto cross-section. **(a)** Gas-phase photochemical production, and loss; **(b)** total transport rate of change. (After Makar et al., 2010.)

Transport from Outside Michigan

- 2007 Canadian BAQS-Met Study showed that the Great Lakes may act as reservoirs for ozone, such that **regional ozone may be increased by about ~30 ppb** due to emissions from surrounding land areas.
- Lake breeze cycle is important in creating this extra regional background ozone and transporting it to SE Michigan.
- We need to understand how much of this pollution is from Canadian sources, versus from Michigan and from other states in the U.S.
- There is a smaller contribution from anthropogenic emissions outside the U.S. and Canada, which requires global models to assess.
- Possibility of a Clean Air Act Sec 179B(b) Petition to demonstrate attainment of ozone NAAQS "but for emissions emanating from outside the United States."

Possible Timetable

- **2019**
  - Seek resources to support SE Michigan-specific modeling analyses (e.g., proposals for federal funding)
  - Secure expertise to develop SE Michigan modeling platform (e.g., collaborative partnerships)
- **2020**
  - Develop modeling platform to inform future 179B/attainment demonstrations
  - Plan for potential field studies in partnership with Environment and Climate Change Canada (ECCC), Lake Michigan Air Directors Consortium (LADCO), and other institutions
- **2021**
  - If feasible/necessary, use modeling platform to support early 179B demonstration
  - Conduct field studies
- **2022**
  - Analyze data from field studies
  - Conduct rigorous performance evaluation of the modeling platform
- **2023**
  - Evaluate control strategies using enhanced modeling platform
  - Submit an enhanced 179B petition (if feasible/necessary) and/or attainment demonstration SIP to EPA

Conclusion

- Work is underway at EGLE to address all ozone non-attainment areas.
- SE Michigan involves some complex modeling issues due to combination of lake breeze and urban heat island.
- Western Michigan ozone non-attainment is somewhat less complex, although lake breeze is important there as well.
- Transport of pollution from outside Michigan is important in both SE and Western ozone non-attainment areas.
- Partnerships (e.g., with LADCO, ECCC) are a key strategy element.
- Enhanced modeling for SE Michigan will also benefit Western Michigan (e.g., quantifying transport influence over Great Lakes).

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